Global Hydrology Resource Center

Data User Guide

ACES Aircraft and Mechanical Data

Introduction

The ACES Aircraft and Mechanical Data consist of aircraft (e.g. pitch, roll, yaw) and mechanical (e.g. aircraft engine speed, tail commands, fuel levels) data recorded by the Altus II Unmanned Aerial Vehicle (Altus II UAV) system during the Altus Cumulus Electrification Study (ACES) based at the Naval Air Facility Key West in Florida. ACES aimed to provide extensive observations of the cloud electrification process and its effects by using the Altus II UAV to collect cloud top observations of thunderstorms. The campaign also worked to validate satellite lightning measurements. The Altus II aircraft and mechanical data files are available from July 10 through August 30, 2002 in MATLAB data format (.mat).

Notice:
Altus II aircraft and mechanical data are not included for each date during the campaign.

Citation

Blakeslee, R., Douglas Mach, and Richard Wohlman. 2020. ACES Aircraft and Mechanical Data [indicate subset used]. Dataset available online from the NASA Global Hydrology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/ACES/MULTIPLE/DATA101

Keywords:

NASA, GHRC, ACES, GA-ASI, Altus II, UAV, navigation data, mechanical data, GPS, INS, cloud electrification

Campaign

The Altus Cumulus Electrification Study (ACES) was a cloud electricity research project aimed at gaining insight into the cloud electrification process and its effects. The ACES campaign goals were to provide a deeper understanding of the storm electric budget, the lightning-storm relationship, and to validate measurements from the space-borne

Lightning Imaging Sensor (LIS). The campaign was based at the Naval Air Station Key West in Key West, Florida (Figure 1). During August of 2002, ACES researchers conducted flights over thunderstorms in southwestern Florida using an unmanned aerial vehicle (UAV) carrying electric field sensors, optical sensors, and other instruments. The Altus II UAV was designed by General Atomics Aeronautical Systems, Inc. (GA-ASI) and NASA. Altus II's high-altitude flying capabilities allowed scientists to collect cloud electrification data from above the cloud level during the entire lifecycle of a thunderstorm. The use of Altus II in this experiment not only served as a way to collect cloud electrification data safely, but also served as a test for use of UAVs in science data collection. More information about ACES can be found on the ACES Field Campaign webpage.

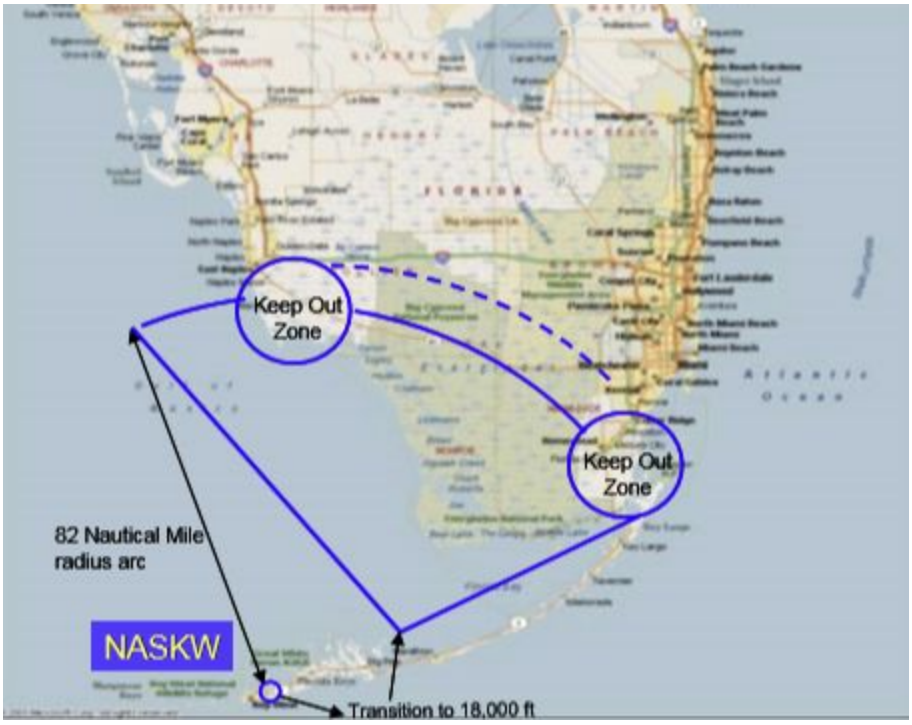

Figure 1: ACES Field Campaign Study Area in southern Florida
(Image source: Blakeslee et al., 2002)

Instrument Description

The Altus II Unmanned Aerial Vehicle (UAV) is a remotely-piloted high-altitude research aircraft developed by GA-ASI in partnership with NASA (Figure 2). It is a version of the GA-ASI Predator surveillance aircraft that has been modified for use in scientific research operations. The entire Altus II UAV system consisted of the Altus II aircraft, a ground control station, a ground data terminal, and the ground support equipment. Altus II offered a unique set of capabilities for data collection during the ACES campaign. It has a flight altitude range of 40,000 to 55,000 feet, giving it the ability to attain cloud-top observations; ideal for validation of satellite estimates. Its slow flying speed and long endurance allow it to collect almost continuous observations of the entire life cycle of a thunderstorm.

Altus II was used to gather lightning and cloud electrification measurements in and around thunderstorms. It carried a variety of instrumentation to measure these electric cloud environments including electric field mills, a "slow" antenna, an optical pulse sensor, search coils, a magnetometer, and a Gerdian conductivity tube. These instruments provided an extensive view of electrical activity in and around the thunderstorms. The use of Altus II also demonstrated the capabilities of UAV platforms for science observations and data collection. More information about the Altus II UAV platform is available on the NASA Armstrong Altus II Factsheet webpage and in the ACES proposal documentation.

Figure 2: The Altus II UAV
(Image source: NASA Altus II webpage)

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Data Characteristics

The ACES Aircraft and Mechanical Data files contain aircraft data (e.g. pitch, roll, yaw) and mechanical data (e.g. aircraft engine speed, tail commands, fuel levels). These data are stored as daily TAR archive files. Inside each TAR file are the aircraft and mechanical data files in MATLAB (.mat) file format. These data are available at a Level 1B processing level. More information about the NASA data processing levels is available on the EOSDIS Data Processing Levels webpage. The characteristics of this dataset are listed in Table 1 below.

Table 1: Data Characteristics

Characteristic	Description
Platform	Altus II Unmanned Aerial Vehicle (Altus II UAV)
Instrument	Litton LN-100G Inertial Navigation System/Global Positioning System (LN–100G INS/GPS); Flight payload data system (FPDS)
Spatial Coverage	N: 26.0, S: 23.0, E: -81.0, W: -85.0 (Southwestern Florida)
Spatial Resolution	Point
Temporal Coverage	July 10, 2002 - August 30, 2002
Temporal Resolution	Daily
Sampling Frequency	Aircraft data: 0.1 seconds Mechanical data: 1 second
Parameter	Navigation data and mechanical data
Version	1
Processing Level	1B

File Naming Convention

The ACES Aircraft and Mechanical Data files are available in MATLAB format and are named using the following contention:

Tarred Data Files: aces1am_2002_<DDD>.tar
Untarred Data Files: [A|M]<mmm><nnn>.mat

Table 2: File naming convention variables

Variable	Description
DDD	Three-digit Julian day
[A|M]	Data type indicator (A or M): A = Aircraft data M = Mechanical data
mmm	Three-digit mission number
nnn	Sequence number
.tar	TAR archive file
.mat	MATLAB data file

Data Format and Parameters

The ACES Aircraft and Mechanical Data consist of navigation, controls, and telemetry data retrieved from the Altus II aircraft. These data were processed using MATLAB and therefore are available as (.mat) MATLAB data files. The *.mat* files are stored inside daily TAR archive files containing all the data recorded on that day (the day indicated by the Julian day in the filename). Upon unzipping a TAR file, there will be a folder containing two types of data files: aircraft data files (A######.mat) and mechanical data files (M######.mat). For each file type, there are multiple files; each covering a different time period during that day. Upon opening one of these files in MATLAB, they will contain three variables. For the aircraft data files, the three variables are: *a_units*, *a_name*, and *aero*. For the mechanical data files, the three variables are: *m_units*, *m_name*, and *data*. The three variables correspond to the units, field names, and data values, respectively. The aircraft data values are recorded every 0.1 seconds while the mechanical data values are recorded every 1 second. Table 3 lists the field names and units for each data field in the aircraft data files.

Table 3: Aircraft Data Fields (A######.mat)

Field Name	Description	Unit
1	GPS Time	sec
2	Roll Stick	degrees
3	Pitch Stick	degrees
4	Yaw Stick	degrees
5	Throttle Cmd	%
6	Flap Stick	degrees
7	Prop P Cmd	%
8	RPM Cmd	rpm
9	Mag Head Cmd	degrees
10	Airspeed Cmd	kias
11	Roll Angle	degrees
12	Pitch Angle	degrees
13	Yaw Rate	degrees/sec
14	L Ail Fdbk	degrees
15	R Ail Fdbk	degrees
16	L Tail Fdbk	degrees
17	R Tail Fdbk	degrees
18	Norm Accel	g
19	Compass Head	degrees
20	VSI	fpm
21	AOA	degrees
22	Airspeed	kias
23	Engine Speed	rpm
24	TAP	%

25	Radar Alt AGL	ft
26	INS Roll	degrees
27	INS Pitch	degrees
28	INS Heading	degrees
29	INS Altitude	ft
30	INS R-rate	degrees/sec
31	INS P-rate	degrees/sec
32	INS Y-rate	degrees/sec
33	INS Norm Acel	g
34	INS VSI	fpm
35	MAP	in. Hg
36	Wastegate Fbk	%

The mechanical data files contain hundreds of variables for the aircraft's mechanical equipment such as gear and brake temperatures, power levels, and fuel levels. These fields are viewable in the *AM_unit.xls* file available in the ACES dataset documents folder. Inside this file, the aircraft data field names are listed first, followed by the aircraft data units, the mechanical data field names, and the mechanical data units.

Algorithm

The Altus II UAV used a Litton LN–100G INS/GPS navigation system. An aircraft's Inertial Navigation System (INS) functions by sensing accelerations from a gyro-stabilized platform. The system computer then uses the INS and Global Positioning System (GPS) information to determine the location, altitude, orientation, and course of the aircraft. More information about the Altus II navigation system is available in the LN-100G GPS Inertial Navigation system information sheet.

Quality Assessment

The Altus II UAV was selected for the ACES field campaign because it had proven its capabilities in operations similar to those required for ACES. As previously noted, the Altus II is a modified version of the GA-ASI Predator aircraft, which had already completed thousands of flight hours demonstrating its high-altitude flying ability. ALTUS II had also proved that it could carry the necessary instrument payload during another research activity prior to ACES. More information about the Altus II UAV performance qualities is available in the ACES proposal documentation.

Software

The ACES aircraft and mechanical data files were processed and stored in MATLAB format (.mat). MATLAB software requires a purchased license. The *ACES_Toolkit.tar* file, available with the ACES dataset, offers various functions and tools that can be imported and used to process the ACES data in MATLAB. Information on the ACES toolkit and MATLAB software is listed in Table 5 below.

Table 5: Software/Tool Information Table

Name	Type	Access	Software	License
ACES_Toolkit	Data visualization and analysis	Link	MATLAB	Required

Known Issues or Missing Data

The only days included in this dataset are July 10-12 and August 2, 4, 6, 8, 10, 12, 13, 15, 21, 23, 25, and 30.

References

Blakeslee, R. J., Mach, D. M., Desch, M. D., Goldberg, R. A., Farrell, W. M., & Houser, J. G. (2002). The Altus Cumulus Electrification Study (ACES): A UAV-based Science Demonstration. *AIAA's 1st Technical Conference and Workshop on Unmanned Aerospace Vehicles, Systems, Technologies, and Operations*.
https://doi.org/10.2514/6.2002-3405

NASA (2014). NASA Armstrong Fact Sheet: Altus II.
https://www.nasa.gov/centers/armstrong/news/FactSheets/FS-058-DFRC.html

Related Data

All data collected during the ACES field campaign are considered related. These data can be located by searching the term 'ACES' in the GHRC HyDRO2.0 search tool and are listed below:

ACES TIMING DATA
http://dx.doi.org/10.5067/ACES/CLOCKS/DATA101

ACES LOG DATA
http://dx.doi.org/10.5067/ACES/ALTUS/DATA101

ACES CONTINUOUS DATA
http://dx.doi.org/10.5067/ACES/MULIPLE/DATA101

ACES ELECTRIC FIELD MILL
http://dx.doi.org/10.5067/ACES/FIELDMILL/DATA101

ACES TRIGGERED DATA
http://dx.doi.org/10.5067/ACES/MULTIPLE/DATA102

Contact Information

To order these data or for further information, please contact:

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Created: 02/14/20